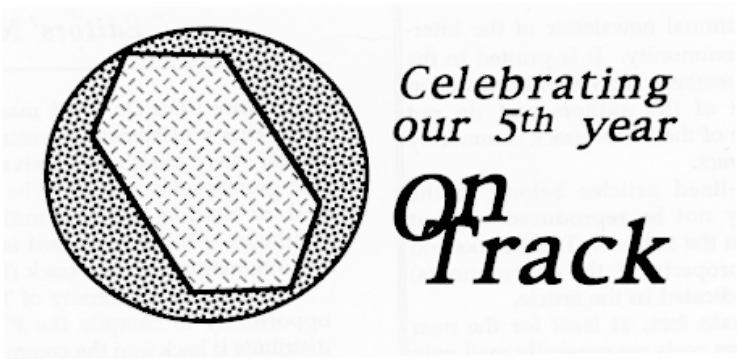

The Newsletter of the International Fission-Track Community

May 1995, Volume 5, Number 1, Issue 10

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In this Issue:

On Track is a biannual newsletter of the international fission-track community. It is printed in the months of May and November. The views expressed in *On Track* are those of the authors and do not necessarily reflect those of the fission-track community or the editor(s) of *On Track*.

On Track will remain free, at least for the near future. However, to save costs we generally mail only one copy per lab so please be sure to pass *On Track* around your lab.

Printing and mailing costs for this issue of *On Track* were paid for by a monetary donation from Donelick Analytical, Incorporated and paid advertisements. Full, half, and quarter page advertisements for this issue were purchased for US$ 200, US$ 100 and US$ 50, respectively. Contact the next editor for advertising prices in the next issue of *On Track* . There is no charge for "short" ads by non-commercial entities (e.g., universities). Send inquiries concerning this issue of *On Track* to the current editor. Send inquiries concerning the next issue of *On Track* to the next editor.

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Editors' Notes

Issue 10 of *On Track* marks the fifth year of the newsletter's existence, a testament to its worthiness! Nearly every month we received requests from people and groups who wished to be added to the directory and/or mailing list, an indication that *On Track* continues to bring important issues to the attention of the international fission-track (FT) community.

We at the University of Texas have enjoyed this opportunity to compile the FT news sent to us and distribute it back into the community. This publication continues to exist because of the contributions sent in by individuals.

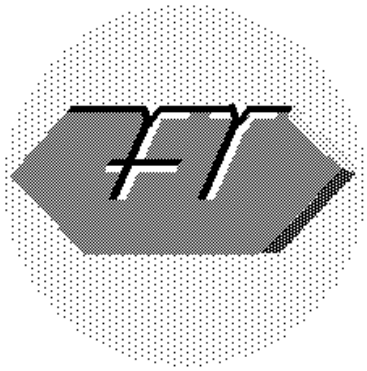
In this issue **Peter Van den haute** and **Frans De Corte** make the first official announcement of the 8th International Workshop on Fission Track Dating. **Maria Balestrieri** and the Pisa FT group bring us up to date on the status of irradiating FT samples in Italy. **Dr. K. D. Bal** informs us of the progress made in India's new FT laboratory.

In response to the article on free FT software in issue 9 of *On Track*, **Kerry Gallagher** is offering a Macintosh based thermal modeling program named MONTE TRAX. This versatile program allows the user to choose between seven published FT annealing models and two probabilistic simulations based on real FT data. **David Coyle** introduces us to the concepts of object oriented programming and applications to thermal modeling of FT data. *On Track* is going electric! **Stefan Boettcher** has put issues 9 and 10 on the World Wide Web and is asking for input regarding the future of this new format. **Jon Linn** fills us in on his dissertation FT research in the Sevier belt of Central Utah.

Last but not least, we would like to introduce the next editor of *On Track,* **Ruth Siddell**. In 1994 she finished her dissertation entitled *Thermotectonic Evolution of the Bay of Biscay Continental Margins: A study using apatite fission-track analysis* under the tutelage of Dr. T. Hurford at University College London (UCL). Presently Ruth is employed as a lecturer at UCL. In her "spare time" she is conducting fission track thermochronologic research in the Massif Central (France) and the Cornubian Massif (United Kingdom), both Variscan (a.k.a. Hercynian) granitic massifs, and in the western Himalayas. These are collaborative research projects between the FT research groups at UCL and Royal Holloway and Bedford New College, University of London.

As the next editor of *On Track* Ruth will lead us into the newsletter's 6th year in print. Please make it as easy for her as it was for us by continuing to send in any and all news the FT community needs to know about.

Official Announcement of the 8th International Workshop on Fission-Track Dating



As was preliminarily announced at ICOG (Berkeley) and the SSNTD conference (Dubna), the next International Workshop on Fission-Track Dating will be held in

Gent, Belgium

The official workshop dates are

26-30 August, 1996

The Gent International Workshop has set as major ambitions to define the present status of the FT methodology and data interpretation and to identify future directions. >

Organization of the workshop is a collaborative effort of the Geological Institute (Peter Van den haute) and the Institute for Nuclear Sciences (Frans De Corte) of the University of Gent.

The first official circular will be sent off in June of this year. The eager and impatient can obtain more information by contacting us at the address, phone, facsimile, or e-mail numbers listed below.

8th International FT- Dating Workshop
Geological Institute, University of Gent
Krijgslaan, 28, B-9000 Gent, BELGIUM.

Phone: +32 (0) 9 264/ 4592 or 6627
Fax: +32 (0) 9 264 4984
E-mail: FTWORK@inwchem.rug.ac.be

A new irradiation facility for fission-track dating in the University of Pavia reactor

Maria Laura Balestrieri[1], Giulio Bigazzi[2] and Massimo Oddone[3]

[1] Dipartimento di Scienze della Terra, via S. Maria, 53, 56126 Pisa, Italy
[2] Istituto di Geocronologia e Geochimica Isotopica, CNR, via Cardinale Maffi, 36, 56127 Pisa, Italy
[3] Dipartimento di Chimica Generale, viale Taramelli, 12, 27100 Pavia, Italy

Other colleagues have very probably experienced disappointment caused by changes of characteristics of irradiation facilities or by closure of the reactor used systematically for the irradiations. This has occurred two times to the Pisa fission-track group: about 15 years ago the CAMEN 5 MW reactor (Pisa) stopped its activity, more recently, the best facility for fission-track dating available at the TRIGA Mark II reactor (0.25 MW) of the University of Pavia was made inaccessible by a long term physics experiment. We had to move to a less thermalized facility, called Lazy Susan (LS). This was unaffected by flux spatial gradients, but its thermalization is not ideal for fission-track dating (cadmiun ratio 6.4 for gold and 48 for cobalt).

Very recently the physics experiment finished, and it was possible to organize a new irradiation facility which is more satisfactory for fission-track dating, called thermal column (TC).

Irradiation tests showed the following characteristics:

Neutron flux. Au and Co monitors detected a thermal flux of 8.36 x 10^9 s^{-1} cm^{-2} and 8.40 x 10^9 s^{-1} cm^{-2}, respectively, in irradiation number P36, and a flux of 8.33 x 10^9 s^{-1} cm^{-2} (Au) and 8.48 x 10^9 s^{-1} cm^{-2} (Co) in irradiation number P37. Mean neutron fluences ([[Phi]]) determined by Au and Co foils in irradiations P36 and P37 (shown below) were in close agreement to those referred to the NIST SRM 962a glass standard when the average of the Cu and Au NIST calibrations was used.

[[Phi]] (Au, Co, P36) = 0.906 x 10^{15} cm^{-2}
[[Phi]] (962a, P36) = 0.924 x 10^{15} cm^{-2}
[[Phi]] (Au, Co, P37) = 1.041 x 10^{15} cm^{-2}
[[Phi]] (962a, P37) = 1.093 x 10^{15} cm^{-2}

Neutron thermalization. A cadmium ratio of 85.3 for gold and 643 for cobalt was determined in the TC facility. The induced track density measured on a

volcanic glass sample (Monte Arci obsidian, Sardinia, Th/U ratio ~3) irradiated in the TC facility in a cadmium box was found to be reduced by a factor of 896.

Fluence spatial gradients. Au and Co foils did not detect spatial fluence gradients. These fluence values were determined 1 cm (1) and 6 cm (2) above the bottom:

Au(1): [[Phi]] = 0.904 x 10^{15} cm^{-2}
Au(2): [[Phi]] = 0.903 x 10^{15} cm^{-2}
Co(1): [[Phi]] = 0.906 x 10^{15} cm^{-2}
Co(2): [[Phi]] = 0.910 x 10^{15} cm^{-2}

Variation of induced track density in a 7 cm glass slide is shown in figure 1. Although a regression line suggests a gradient of about 0.7 % per cm, the correlation coefficient is very low (0.45). Track density seems to be very homogeneous in the region used for sample irradiation (between 0.5 cm and 5.5 cm above the bottom).

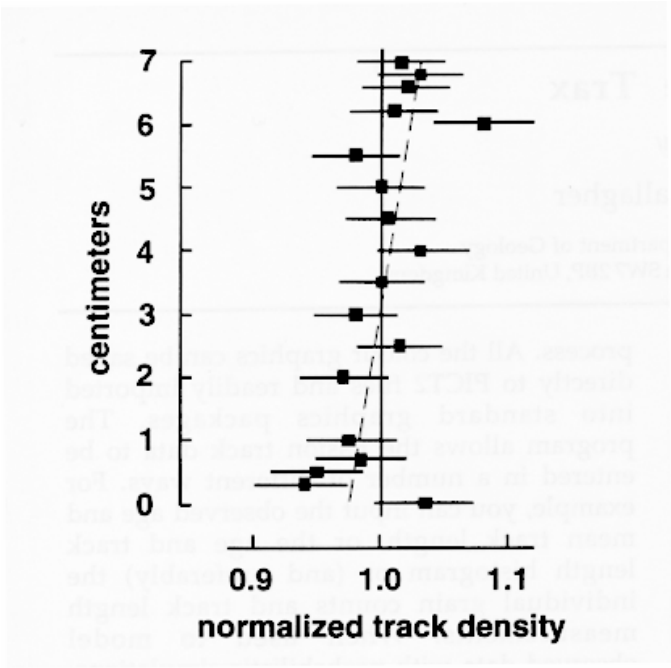


Figure 1. Normalized induced track density determined at different height above the bottom in a glass slide irradiated in the thermal column (TC) position.

Ages determined on age standards (or putative age standards) were found to agree with expected ages:

Fish Canyon Tuff apatite, determined age 27.5 +/- 1.4 Ma ($^{40}Ar/^{39}Ar$ age 27.8 +/- 0.2 Ma); Moldavite glass, determined age 15.2 +/- 0.8 Ma (K-Ar age 15.17 +/- 0.15 Ma); Macusanite glass, determined plateau age 6.07 +/- 0.25 Ma (K-Ar age 5.67 +/- 0.10 Ma); Jas G1 obsidian, determined plateau age 0.97 +/- 0.06 Ma ($^{40}Ar/^{39}Ar$ age 0.945 +/- 0.005 Ma).

The TC facility appears very suitable for fission-track dating. Due to the low thermal neutron flux relatively long irradiation times are needed for the fluences requested by the fission-track dating method. However, the TC facility is relatively free, so week-long irradiations do not represent a problem.

Acknowledgments

We wish to thank Dr. V. De Michele, Dr. C. W. Naeser, Dr. G. Poupeau, Dr. Wadatsumi and N. Kitada for providing test samples.

A New Track on the Horizon

K. D. Bal
KDM Institute of Petroleum Exploration
Oil & Nat. Gas Corporation Ltd., Dehradun, India

In an attempt to bring additional tools to petroleum exploration in India, **Dr. M. Lal, Dr. K. D. Bal,** and **R. S. Waraich** have set up a fission-track (FT) laboratory at the KDM Institute of Petroleum Exploration (KDMIPE). KDMIPE is the premier R&D institute of the Oil & Natural Gas Corporation Ltd. (ONGC), the single largest petroleum co. in India.

India has a large number of petroliferous sedimentary basins. The ONGC envisions that the FT laboratory's research will concentrate on quantitative modeling of the thermal histories of India's sedimentary basins and characterization of their associated hydrocarbon reservoirs. Vitrinite reflectance has been the main parameter used for thermal history modeling by the ONGC. The ONGC`s only attempt to generate FT data has been in the Ganga Basin. Considering the merits of the FT method, we see a great opportunity to carry out FT studies throughout sedimentary basins in India. Preliminary studies have begun to identify critical basins and bore-holes for evaluation.

At this time all equipment including an automated microscope stage system has been installed in the laboritory. Dr. Bal and R. Waraich are now standardizing laboratory and counting procedures. Unfortunately, Dr. Lal has been reassigned within KDMIPE after playing a lead role over the past three years.

We take this opportunity to convey our sincere thanks to **Dr. C. W. Naeser** and **Dr. A. J. Hurford** for providing age standards, **Dr. D. S. Miller** for providing "unknown" samples for calibration, and **Dr. J. Schreurs** for providing CN glass dosimeters. Finally, we thank **Dr. N. Lal** and **Dr. K. K. Sharma** for their guidance and lectures on current uses of the FT method in petroleum exploration.

Monte Trax

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Prince Consort Road, London SW7 2BP, United Kimgdom

WHAT IS MONTE TRAX ?

Monte Trax is a Macintosh program which can be used to :
(i) calculate fission track parameters (age and length distribution) for a specified thermal history
(ii) constrain the range of thermal histories consistent with observed fission track parameters

HOW DOES IT WORK ?

Monte Trax allows a user to specify a thermal history (as a series of time:temperature points) and calculate fission track parameters (FT age and length distribution) using one of a possible 7 published models for track annealing. This is referred to as the forward calculation, or solving the forward problem, and, in general, will be run once for a given thermal history. Alternatively, the user may input observed fission track parameters and specify bounds on possible time and temperature values. A probabilistic approach (either random Monte Carlo or Genetic Algorithm) is used to select time-temperature points from within these bounds and construct a thermal history. The predicted fission track parameters are then quantitatively compared to the observed values, and the level of agreement between the two is used to assess the thermal histories most consistent with the observed data.

IS IT USER FRIENDLY ?

It is very straightforward to use, incorporating the usual Macintosh pull down menus, dialog boxes, etc. to allow a user to interact easily with the input and data manipulation process. All the colour graphics can be saved directly to PICT2 files and readily imported into standard graphics packages. The program allows the fission track data to be entered in a number of different ways. For example, you can input the observed age and mean track length, or the age and track length histogram or (and preferably) the individual grain counts and track length measurements. When used to model observed data with probabilistic simulations, the user has the capability of selecting individual thermal histories, or a group of thermal histories that predict the observed fission track data to a user specified tolerance. A variety of built in statistical tests determine how well individual thermal histories fit the observed data. Finally, the program comes with extensive documentation and example data files.

WHAT DOES IT RUN ON ?

The program will run on the 68K Macintoshes (those with 68020/30/40 processor and the 68881/2 math coprocessor and also on the LC models with 13" screens, provided a math coprocessor has been installed). There is also a native version for the PowerMacs. These are generally faster than the 68K machines. As yet a Fat Binary (a single application to run on both the 68K and PowerMac machines) is not available.

HOW CAN I GET IT ?

It's not yet available in the High Street or nearest Mall. Contact Kerry Gallagher via e- mail: kerry@ic.ac.uk or the address listed above for details.

Annealing, Objects, and Distributed Computing

David A. Coyle
Max Plank Institut-Kernphysik, Heidelberg, Germany

This short article is to inform you all about the current project that I am working on, in addition to the KTB *in situ* annealing studies. It has to do with finding a way to run random or directed search thermal history programs, in a way that is a) easy, b) cheap, and c) allows arbitrary (high) precision. How the time-temperature space is sampled is not important for this discussion, so if you're a fan of Genetic Algorithms, Neural Networks, or just plain old Monte Carlo searches, there's still something here for you.

My approach is to use objects. Oh, not just any objects, like the screen-painted buttons that Visual Basic gives you. No, I mean real objects, using a completely object-oriented operating system, and Objective-C (unlike C++, Obj-C allows *run-time binding*.). I was once asked "What's the difference between an object and a subroutine?" I think that this article should make that clear, but first and foremost, an object has a "life" of it's own. It does not need to exist in the context of a larger program, and it does not need to go away when that program terminates. But it is also not a program on its own, mainly because it does not have its own event loop. An object exists, and performs actions in response to messages that it receives from other objects. A secretary, sitting in her office, won't (necessarily) be doing anything until the phone rings, the intercom buzzes, the boss calls her in for dictation, whatever. The secretary is a self-contained entity and can be picked up and placed in another office, and begin to work immediately. She can also respond to different messages, and take the appropriate action. Subroutines, on the other hand, have only one entry point, and can perform only limited actions with limited data. A subroutine is more like the government, only doing one thing: taking your money, and spending it.

So how do objects fit into annealing? The basic plan for my object system is shown in figure 1.

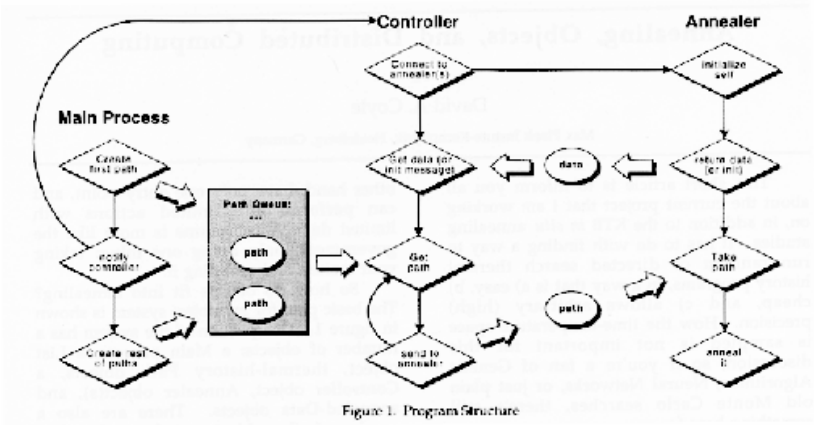

Figure 1. Program Structure

Figure 1. Program Structure

This portion of the system has a number of objects: a Main process, a List object, thermal-history Path objects, a Controller object, Annealer object(s), and annealed-Data objects. There are also a number of other objects not shown, but they are not important right now. The important thing to note is that data are not variables, they are totally separated from the processes. This is an important abstraction, because as one follows the system, one sees that the various procedure objects do not need to keep the data any longer than they operate on it. Once the Annealer is finished annealing the path, it includes the path with the calculated parameters and sends it back to the Controller. The data itself is never copied, it is passed from process to process, as needed. Thus there is no need to keep track of numerous arrays, for example. More importantly there is no need to make sure that one frees the arrays when done with them.

Let's follow a path through the system, to see what happens to it. First, the main Process creates a time-temperature Path object. It then shifts that object into a Queue. The Process now does not own the path, nor does it retain any reference to it. Next, the Process informs the Controller that there is data in the queue, and goes on to create more paths, using Monte Carlo, GA, etc. The Controller, being in a separate *thread* (an independent process), can now act on its own. It consults its list of available Annealer objects, and connects to them. Once connected, the Controller takes a path out of the queue, and passes it to the next available Annealer, which is also in its own thread. The Annealer anneals it, and passes the path plus the data back to the Controller. The Controller (or another object) evaluates the data, and either eliminates the object, if the data is not useful, or archives it. Then the Controller takes another path from the queue, and passes this to the now-idle Annealer. And so on, until all paths have been processed. The important part is that the Controller does not need to know which Annealer is doing what. When any Annealer is finished, it contacts the Controller. So, for example, if there are two Annealer objects, one on a fast machine, and one on a slow machine, the fast machine may get two paths annealed for every one that the other machine processes, but the Controller never waits for the response from a specific Annealer: any Annealer will do. So how does distributed computing fit into the picture? Well, that is shown in figure 2.

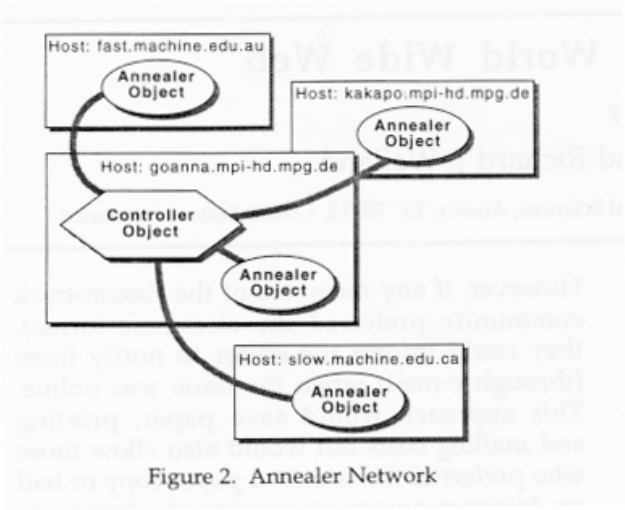

Figure 2. Annealer Network

Figure 2. Annealer Network

Because the Annealer objects are independent of the Controller, there is in fact no requirement that they be a) compiled into this program, and b) on the same computer, or c) even on the local network. By splitting the problem and distributing it around, we are now able to evaluate thermal histories with a precision like never before. We can do searches with not just the measly tens of tracks/timesteps and hundreds of paths that are common to current programs, but with thousands, or tens of thousands. At the very least, we can routinely track the number of fission-tracks that are actually measured in the samples, be it 500, or 1500. I've tested the Annealer object with up to 10,000 tracks/ timesteps: it's slow, but it works. And this is on a machine that's not much faster than a Pentium. If I could place the Annealer on a DEC Alpha workstation (Portable Distributed Objects run on DEC OSF/1), then it'd be pretty zippy, even at that resolution. Of course, you have lots of questions:

Q: Isn't this distributed object stuff hard? Connecting to a remote object, across the Internet, yikes!

A: You couldn't be further from the truth.
I said at the beginning that I'm using a real object-oriented system. Here is the procedure for connecting to a remote object. From the remote object side, we just need to include these methods: myConnection = [NXConnection registerRoot:self withName: REGISTERED_NAME]; [myConnection run]. For an Annealer object, we would make the registered name ANNEALER. From the controller side, we need to implement these two methods: server = [NXConnection connect-ToName: REGISTERED_ NAME onHost:"machine.site.edu"]; myConnection = [server connectionForProxy]; You now send messages to the remote object through this proxy: [myConnection doSomething]; The only real constraint is that the remote object must make itself available first, but that's easily accomplished using a daemon process that starts when the machine is booted.

Q: But naturally this is prohibitively expensive for us mere mortals...

A: Well, the US price for the NextStep Academic Bundle (on 2 CD-ROMs) is $300, which includes everything, especially the develop-ment tools. And, NextStep will run on most hardware platforms: Intel, Hewlett-Packard PA-RISC workstations, Sun SPARC work-stations, and good ol' NeXT "slabs" and "cubes". The system independent version, OpenStep, will run this year on Solaris, OSF/1, WindowsNT & 95, and also a free version, the "GnuStep" is being created that will run on any other UNIX system (Linux, HP-UX...). PDO for foreign operating systems is more expensive, though.

Q: This is just a concept: it's not real, is it?

A: Well, the Annealer object exists already: I use it all the time, and the controller object is just an accountant that could be written and debugged in a day or two. The real constraint is the engine that creates the temperature-time paths, because we want to make different engines and evaluators *dynamically loadable*: able to be attached to the program without recompiling. I'm working on a graphic interface for constraining the paths in *t-T* space right now (where you draw boxes in a view). For that the icon, the cursors, and mouse-driven events are near-complete, and only the drawing code and the actual path generator need to be coded. ***If*** I can get two weeks of solid programming time, then this will all be ready (that is a big "if", by the way). Of course, if you want to help, it will be ready sooner. In any case, it should be real by the time of the next FT Workshop, because I would like to demo it there.

So, you see, real computing isn't that hard, nor is it necessarily expensive. One of the things that I like about the NextStep operating system is that it scales upwards. Most power-users of DOS or Macs are frustrated, because they usually already have the fastest machines they can get. Machines that run NextStep *start* at the Pentium level, and only get (much!) faster (I've actually got the *slowest* Hewlett-Packard workstation that they make). So you can test a concept cheaply on a Pentium: when you see that it works, and that you need more speed, you can just buy a faster machine. If your program runs on DOS or Mac and you want a faster machine, well, you're in trouble, because either you just have to wait, or if you switch to a workstation, most (more likely all) of your program will need to be rewritten.

On Track and the World Wide Web

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After completing the last two issues of *On Track* (numbers 9 and 10), we decided to follow the suggestion of John Garver (Union College, New York) and make the issues available through the University of Texas Geology Library home page on the World Wide Web. The URL (Universal Resource Locator) address for the University of Texas Geology Library home page is URL = `**http://www.lib.utexas.edu/Libs/GEO/geology.html**'. Issue number 9 of *On Track* can be accessed from this site by scrolling down the page and clicking on the underlined "full text of the current newsletter". After issue number 10 is released, we will update the entry to indicate the availability of both issue 9 and issue 10 online. The html (hypertext markup language) format was created by first opening Microsoft Word 5.1 and saving the document as an rtf (rich text format) file. Next, rtftohtml-mac software was used to automatically create the html file. At this point, manual editing (by Jim McCulloch, Univ. of Texas Librarian) was required to arrive at the final format as the automated rtftohtml-mac software as not able to reproduce all the formatting we desired. The entire process took about 3 hours to accomplish.

We consider the WWW format to be experimental and are eager to hear feedback regarding the style, potential problems, and role the electronic format should have in distributions of future issues. Our first inclination was to have the electronic format serve as an effective archiving site for back issues of *On Track*. In this way, new practitioners and scientists outside of the international fission-track community could easily access both new and old issues.

However, if any members of the fission-track community preferred the electronic format, they could inform the editor to notify them (through e-mail) when the issue was online. This approach would save paper, printing and mailing costs but would also allow those who preferred the standard paper copy or had no Internet access to receive the issues as usual. Furthermore, the html format would be platform independent, allowing Mac, DOS, and UNIX users to access the document without regard to system compatibility.

In our discussions with previous editors, a number of issues have arisen concerning preparation of electronic versions of back issues of *On Track*. A common concern was that hard copies of previous issues contained illustrations and/or photos that were glued on to paper before the whole issue was sent off for printing. Thus, no computer version of the illustrations are available to facilitate conversion to the GIF (graphics interchange format) images necessary for accessibility by web browsers. GIF images have no particular format, they are just byte representations of the image, one to four bytes or so per pixel. We were able to quickly overcome this problem for the cartoon on page 6 of issue number 9 by scanning the figure, then saving it as a GIF image in Adobe Photoshop™. Advertisements pose a greater problem, as special fonts or border designs may not be compatible with GIF images (there are no fonts in GIF files, just the image). In issue 9, we had to simplify the border designs of one advertisement because of this problem.

Aside from these relatively minor technical difficulties, a more serious issue involving web availability involves *On Track* articles that may have been superseded by more up to date journal articles. Authors could, however, ask editors to establish links to the newer publication and leave the old one for historical purposes. Copyright laws will be an issue only if the journal article and the *On Track* article are identical. In any case, it is important for the fission-track community to be aware of the issues involved with the electronic medium and to provide feedback before a commitment is made to make all issues available on the World Wide Web.

Because we are passing on our editorial responsibilities after this issue, we will let the next editor decide whether or not they wish to continue with the electronic format. If previous and future editors do decide to make *On Track* issues available online, we believe that it is best for individual editors to do the html formatting, provide an access site (server), and establish links to other sites where *On Track* issues are available for the public. However, if past editors would rather not undertake such an endeavor, we are willing to do html formatting during the next year (1995-1996). Please address any comments regarding the pros and cons of *On Track* online availability to:

Stefan S. Boettcher
Assistant Editor of *On Track* (1994-1995)
Dept. of Geological Sciences, University of Texas at Austin
Austin, TX 78712

or via E-mail: sboett@maestro.geo.utexas.edu

Short Tracks: News

Ed Sobel has finished his Stanford Ph.D. and moved to France. Look for a paper in Tectonics later this year regarding his work on Himalayan exhumation around the margins of the Tarim Basin in western China. Ed has a post-doc with argonist Nick Arnaud at the University of Clermont-Ferrand. He collected FT samples from the Altyn Tagh fault on the northern boundary of Tibet last summer, and if they ever emerge from the shipping maze, will work on them in Diane Seward's lab at E.T.H.-Zürich.

Trevor Dumitru, **Elizabeth Miller**, and **Roland Bürgmann** (Stanford) recently had two N.S.F. grants funded, one for Basin and Range extension in Utah, Nevada, and California, and one for neotectonics and seismic hazards along the San Andreas fault system around San Francisco. **Danny Stockli** will work on the Basin and Range project as part of his Stanford Ph.D. Danny is now finished with his master's degree at E.T.H.-Zürich. Repair of the Stanford Geology Corner, closed by the 1989 earthquake, is now underway, and parts of the FT set-up will move to this beautiful old building in about a year.

Although now stationed at the University of Texas at Austin, **Pete George** continues the post doctorate work he started at the University of Wyoming. Pete is dating and measuring track lengths in apatite from Paleocene conglomerates of the Hanna Fm. in the Hanna Basin of Wyoming. The ages are roughly equivalent to their depositional ages. Mean track lengths range between 13.4 and 14.1 um indicating the apatite have been partially annealed. The source area for these arkosic strata (a section ~3 m thick) is probably the Granite Mtns. to the northwest. One possible explanation of these data is rapid exhumation and erosion of the source area in Late Pliocene time and subsequent transport and burial in the northwestern part of the Hanna Basin. Partial annealing is assumed to have occurred during burial in Late Pliocene-Early Eocene time. Soon thereafter, these rocks were probably folded, uplifted, and exumed along the Shirley Thrust in Wasatchian time. Future work on this project will include the dating of samples from the Granite Mtns. and a lithologic/mineralogic

comparison between matrix and clasts from the Hanna Fm. and Precambrian rocks in the Granite Mtns.

Timing and thermal characteristics of Sevier belt thrust faulting and synorogenic sedimentation in the Pavant and Canyon Ranges, central Utah

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Purpose of Project:

The complexity of the Sevier orogenic belt in central Utah has left many details about its structural and sedimentological development unresolved. Specifically, the ages of the Pavant and Canyon Range thrusts and details of synorogenic sedimentation in central Utah are debatable (e.g., Lawton, 1985; Villien and Kligfield, 1986; Royse, 1993). Also, the thermal evolution of the Pavant and Canyon Range thrust sheets has not been addressed. Apatite and zircon fission-track analyses are being conducted on the Neoproterozoic Mutual Formation and the Lower Cambrian Tintic Quartzite from the Pavant and Canyon Range thrust sheets and clasts of these quartzites in synorogenic sequences to resolve these problems.

Implementation of fission-track analysis for this study relies on the resetting of the apatite and zircon fission-track clocks by burial and heating of the Mutual Formation and Tintic Quartzite at the base of the thrust sheets prior to thrust faulting. As thrust faulting uplifted the quartzite, erosion resulting in cooling of the thrust front below the zircon and apatite retention temp-eratures. Thus fission-track ages from the quartzites yield indirect information about the timing of thrust faulting and presumably the thermal evolution of the thrust sheet during and after thrusting. Quartzite clasts in synorogenic conglomerates should have undergone similar thermal histories as the quartzite units from which there were derived, so fission-track analysis will be used to place additional constraints on the timing of thrust sheet motion and unroofing.

Results of this project will increase our knowledge about the tectonic development of a part of the Sevier orogenic belt that, at the present time, is not well-constrained. Also, this project will demonstrate that fission-track analysis can be used to constrain the timing of motion of thrust faults and the timing relationships between synorogenic sedimentary rocks and thrust faults in areas where structural reconstructions and sedi-mentological relationships are debatable. Moreover, by using fission-track analysis to constrain the relative ages of the Pavant and Canyon Range thrusts, I hope to show that the technique can be a reliable method for constraining the sequence of thrust development (i.e., forward-breaking vs. backward-breaking).

Results to Date:

Apatite fission-track analysis has been conducted on seventeen quartzite samples from the Pavant and Canyon Range thrust sheets and conglomerates from the Pavant Range and Canyon Range, central Utah. Several important points can be made from the data thus far: 1) Compositional effects play an important role in the single grain fission-track ages in these samples. For each sample, the pooled age for F-Cl-OH apatite is typically older than the pooled age for F-apatite. This is consistent with the FT work being done by Ray Donelick in an adjacent area (see Burtner et al., 1994 for methodology; U.S. Patent Number 5,267,274 to Raymond A. Donelick). 2) Data from quartzite samples collected from the Pavant thrust sheet indicate that it cooled below 130-140[[ring]]C (approximate retention temperature range for Cl-apatite) and 100-110[[ring]]C (approximate retention temperature range for F-apatite) around 60-70 Ma and 40-50 Ma, respectively. Zircon fission-track analysis and thermal modeling are required to assess the relationship between these ages and the actual timing of motion on the Pavant thrust fault. 3) All quartzite samples from the central Canyon Range yielded Miocene fission-track ages. It is unclear at the present time whether these ages represent slow erosional unroofing of the thrust sheet or a younger thermal overprint not related to Sevier belt thrusting (such as Basin and Range tectonism). 4) Fission-track ages from most of the conglomerates fall into two groups. The first group shows F-apatite fission-track ages of around 50 Ma and F-Cl-OH apatite ages of around 70 Ma. The second group shows F-apatite fission-track ages of around 70 Ma and F-Cl-OH apatite ages around 90 Ma. Both groups are represented by conglomerate samples from the Pavant Range and the Canyon Range, so more data is required to assess the tectonic implications of these data. 5) Only two samples yielded enough apatite grains to obtain at least 40 horizontal confined track length measurements. Both samples are from the Pavant thrust sheet and yielded mean track lengths of 11.6+/-2.2 mm (n=55) and 12.8+/-2.4 mm (n=47). Thermal modeling has not yet been conducted on either of these samples.

Future Work:

Future work includes zircon fission-track analysis on all samples which will further constrain the timing of thrust faulting, the maximum temperature the base of the thrust sheets reached prior to thrust faulting, and the overall cooling rate of the thrust sheets as they were uplifted and eroded. Further sample collection is required as well. Sampling will concentrate on the Canyon Range thrust sheet, which has produced the most complex results in the first round of analyses. Quartzite from the Pavant thrust sheet and conglomerates from both ranges will also be collected in order to build a more robust data set.

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Recent Fission-Track Papers

Please send items for future listings in *On Track* to the next editor, Ruth Siddell. The reference or a photo copy of the first page will suffice but a copy of the entire paper is appreciated. We especially want non-fission-track papers that may be of special interest to the fission-track community. Papers in press are welcome, please include an estimate of the expected month of publication. A special thanks to Trevor Dumitru for providing most of the references listed below.

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Call for Contributions to the November 1995 *On Track* issue 11

Dear Fellow Fission Tracker:

The next issue will be printed in November, 1995 and **we are looking for contributions.** We welcome contributions of virtually any kind, including descriptions of new lab techniques, reviews of useful products, news and gossip, raving editorials about what all the other labs are doing wrong (or right), corrections of errors that appeared in the previous issue, meeting announcements, job openings, cartoons, and descriptions of what you are doing in your research.

On Track always includes a list of **Recent Fission-Track Papers**. If you know of a paper that was published recently, or that is in press and should be published in the near future, please send it in. The **Short Tracks: News** section allows all of us to keep up with fission "trekking" around the globe. *On Track* also includes an **International Fission-Track Directory** in each May issue. If you are about to move, have moved, or know of someone who has moved, please inform me so the directory can be updated.

If you would like to contribute, send the final text and figures before the **DEADLINE, 15 October, 1995**. If it is a lengthy article, let me know the title and length as soon as possible. Please send a paper copy of your contribution and a 3.5 inch **Macintosh(TM) compatible disc** with the text saved in Microsoft Word. If you can't send a Macintosh compatible disc, send a 3.5 inch IBM compatible disc in Word, or WordPerfect. Contributions can also be sent electronically. Send all contributions for the next issue of *On Track* to:

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1995 DIRECTORY OF THE INTERNATIONAL FISSION-TRACK COMMUNITY

This directory is published solely for the information of fission-track researchers. It is neither a comprehensive directory including all fission-track researchers nor an official document endorsing the scientific stand of individuals by the fission-track community. We provide here an update to the initial directory prepared by Rasoul Sorkhabi with the hope that we have accounted for the changes in addresses that have occurred since the last release of the directory.

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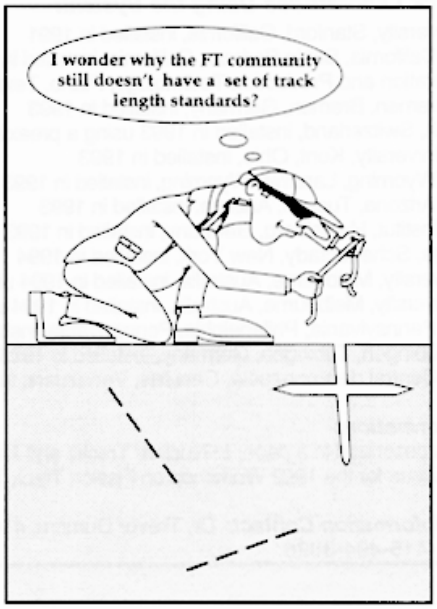

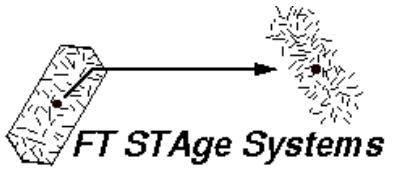

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Fission Track Laboratories Using the System:

- Stanford University, Stanford, California, installed in 1991
- University of California, Santa Barbara, California, installed in 1992
- ARCO Exploration and Production Technology, Plano, Texas, installed in 1992
- Universität Bremen, Bremen, Germany, installed in 1993
- E.T.H., Zürich, Switzerland, installed in 1993 using a preexisting stage
- Kent State University, Kent, Ohio, installed in 1993
- University of Wyoming, Laramie, Wyoming, installed in 1993
- University of Arizona, Tucson, Arizona, installed in 1993
- Max-Planck-Institut, Heidelberg, Germany, installed in 1993 using a preexisting stage
- Union College, Schenectady, New York, installed in 1994
- Monash University, Melbourne, Australia, installed in 1994 using a new Zeiss stage
- La Trobe University, Melbourne, Australia, installed in 1994 using two new Zeiss stages
- University of Pennsylvania, Philadelphia, Pennsylvania, installed in 1995
- Universität Tübingen, Tübingen, Germany, installed in 1995
- Universidad Central de Venezuela, Caracas, Venezuela, installed in 1995

Detailed Information:
The system is described in a paper in Nuclear Tracks and Radiation Measurements, vol. 21, p. 575-580, Oct. 1993 (proceedings issue for the 1992 Workshop on Fission Track Thermochronology held in Philadelphia).

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